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(54) Title: QUALITY CONTROL OF ELECTRO-ACOUSTIC TRANSDUCERS

Block diagram of transient analyser
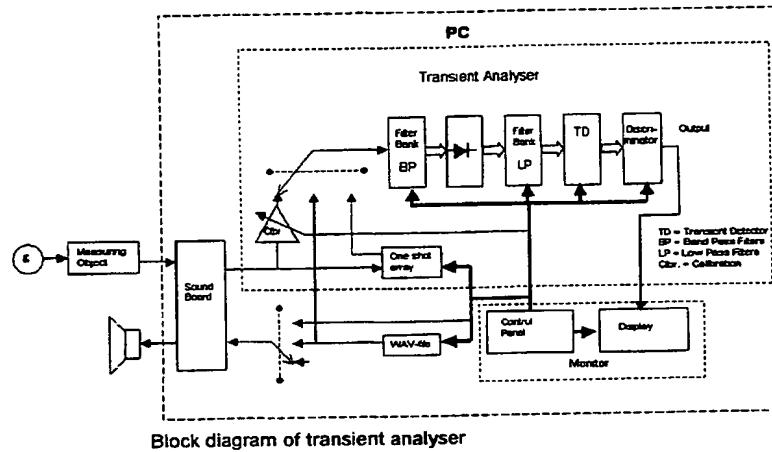
(57) Abstract: In accordance with the invention an excitation signal is fed to the device under test. The excitation signal is preferably a swept or a stepped sine wave signal. A response signal from the device under test is analysed for transients, which preferably involves band pass filtering in one or more distinct frequency bands, rectification of the band pass filtered signals and low pass filtering of the rectified signals. The signals thus analysed for transients are differentiated. After differentiation the signals represent, in each frequency band, the slope or steepness of the response signal from the device under test, and are a good and reliable quantitiative measure of the presence of possible rub and buzz in the deivce under test. In quality control of eg speaker transducers each of these steepness signals is compared to a predefined threshold value. Transducers with steepness values entirely below the threshold value or values will pass the quality control test, whereas transducers with stepness values entirely below the threshold value or values will pass the quality control test, whereas transducers with steepness values exceeding the threshold value in one or more frequency bands, have failed in teh quality control test. Devices that have failed in the test may then be discarded or possibly repaired.

For two-letter codes and other abbreviations, refer to the "Guid-ance Notes on Codes and Abbreviations" appearing at the begin-ning of each regular issue of the PCT Gazette.

Quality control of electro-acoustic transducers

Field of the invention

The invention relates to quality control of eg electro-
5   acoustic transducers, and in particular to a method of
quantitative measurement of non-linearities such as rub
and buzz.

Background

10   The traditional method for measuring the energy of
auditory signal deals with measuring the RMS (root-mean-
square) value of the frequencies in the signal. This
measure is based on the assumption that the signal only
contains steady state frequency components. In the real

15   world this will only be the case in very rare occasions.
Normally signals exhibit dynamic behaviour with varying
instantaneous energy. Pulses in auditory signals can in
fact be expressed as abrupt changes in the instantaneous
energy in the signals.

20

In audio products non-linearities can generate unwanted
pulses that disturb the perceived quality, and can
severely degrade the quality. The generated pulses will
have different duration and energy, depending of the

25   nature of the non-linearity. In some cases the duration
of the pulses will be very short and the mean energy
therefore will be very small even though the maximum
instantaneous energy might have a relative high level.
The traditional method by measuring the harmonic

30   distortion will not be satisfactory in these cases. One
of the classical examples is the distortion in class A
and B amplifiers, where the crossover distortion in a
class B amplifier disturb the ear at a much lower

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harmonic distortion (< 1%) than the harmonic distortion
caused by saturation in a class A amplifier (about 10 –
15%). Mechanically introduced noise in loudspeakers and
microphones, known as "Rub and Buzz", will also occur as
5   short pulses in the signal.

In relation to electro-acoustic transducers, such as
microphones and loudspeakers and speaker transducers for
use in telephones, the phenomenon referred to as "rub and
10   buzz" is mechanically introduced noise caused by non-
linearities in the transducers. These non-linearities are
most often due to imperfections in the process of
manufacturing the transducer, and it can be one or more
of the following defects: loose litz wire, loose
15   diaphragm, loose coil, misplaced diaphragm, scraping or
dragging coil, air leak or other defects. These defects
create short pulses due to abrupt changes in the
instantaneous energy and are very disturbing to the human
ear. The short impulses have relative low energy, and it
20   can be difficult to detect the pulses when the signal is
averaged using traditional RMS-FFT techniques. On the
other hand, the maximum changes in the instantaneous
energy are relatively high and can easily be detected
with the measurement technique described here.
25

Traditionally, Quality Control (QC) of audio products
such as loudspeakers includes measurement of the
frequency response, the impedance and rub and buzz. The
measurement of the frequency response and the impedance
30   are performed using well-known techniques such as FFT,
MLS or TDS and apart from a careful design these
measurements usually do not cause problems. Rub and buzz

is measured in different ways e.g. by tracking the
harmonics using a swept sine or some kind of swept two-
tone complex. These traditional rub and buzz measurement
techniques usually have an inadequate performance and are
5   the Achilles heel of QC systems. This invention provides
a method of measuring rub and buzz, which easily detects
rub and buzz in loudspeakers and other audio products.

The method of the invention performs detection of the
10 changes in the instantaneous energy as perceived by the
human ear.

Further background can be found in the documents
US 5 884 260, WO 97/09712, WO 99/48085 and also in [1]
15 and [3], which are all incorporated herein by reference.

Summary of the invention
In accordance with the invention an excitation signal is
fed to the device under test. The excitation signal is
20 preferably a swept or a stepped sine wave signal. A
response signal from the device under test is analysed
for transients, which preferably involves band pass
filtering in one or more distinct frequency bands,
rectification of the band pass filtered signals and low
25 pass filtering of the rectified signals. The signals thus
analysed for transients are differentiated. After
differentiation the signals represent, in each frequency
band, the slope or steepness of the response signal from
the device under test, and are a good and reliable
30 quantitative measure of the presence of possible rub and
buzz in the device under test.

In quality control of eg microphones and speaker transducers each of these steepness signals is compared to a predefined threshold value. Transducers with steepness values entirely below the threshold value or

5 values will pass the quality control test, whereas transducers with steepness values exceeding the threshold value in one or more frequency bands, have failed in the quality control test. Devices that have failed in the test may then be discarded or possibly repaired.

10

Brief description of the drawings
Figure 1A shows the sound output from eg a loudspeaker excited by a sine wave sweep, where the loudspeaker suffers from rub and buzz,

15

Figure 1B shows the signal in Figure 1A after band pass filtering,

Figure 1C shows the instantaneous energy pulses caused by

20 rub and buzz,

Figure 2A shows schematically a set-up for transient analysis,

25 Figure 2B shows a schematic block diagram for energy detection by means of envelope detection,

Figure 3A shows a series of measurements of a good transducer without rub and buzz,

30

Figure 3B shows a series of measurements of a transducer suffering from rub and buzz,

Figure 4A shows a series of measurements of a good loudspeaker without rub and buzz,

5   Figure 4B shows a series of measurements of a loudspeaker with dragging coil,

Figure 4C shows a series of measurements of a loudspeaker with litz wire defect,

10

Figure 5A shows a series of measurements of a good tweeter without rub and buzz,

Figure 5B shows a series of measurements of a tweeter

15   with dragging coil,

Figure 5C shows a series of measurements of a tweeter with air leak,

20   Figure 6 shows a block diagram of a transient analyser used in the invention,

Figure 7 illustrates the principle of edge detection, and

25   Figure 8 illustrates the principle of masking edge detection.

Detailed description of the invention

The method by which the rub and buzz is detected according to the invention is

30   based on detection of changes in the instantaneous energy by means of transient analysis. Theoretically, acoustic energy in a sound signal consists of kinetic energy and potential energy, and the total energy $E(t)$ is the sum of the kinetic energy and the potential energy, which can be expressed by the following formula:

$$E(t) = f^2(t) + \hat{f}^2(t) \qquad\qquad (1)$$

where $\hat{f}(t)$ is the Hilbert transform of $f(t)$, and $f^2(t)$ and
$\hat{f}^2(t)$ can be interpreted as the kinetic and potential
5   energy, respectively. For a pure sinusoidal sound signal
the total energy is constant. If $f(t) = \sin(\omega t)$, then
$\hat{f}(t) = -\cos(\omega t)$, and consequently, $E(t) = \sin^2(\omega t) + \cos^2(\omega t) = 1$, ie
a constant.

10   Ideally, when applying a sinusoidal signal to a
loudspeaker the total energy measured acoustically, ie
sound energy, should be constant, and therefore no
changes in the instantaneous energy would be detected.
However, if the loudspeaker suffers from rub and buzz,
15   the instantaneous energy will no longer be constant, and
the rub and buzz can then be detected by detecting the
relatively abrupt changes in the energy. Figures 1A-C
show the result from an analysis of a loudspeaker
suffering from rub and buzz when a swept sine is applied.
20
Figures 1A-C show both the time signal and the total
instantaneous energy. In Figure 1A it can be seen that
the amplitude of the sine wave signal is varying, which
means that the energy is not constant. The abrupt changes
25   reveal the rub and buzz. In figure 1A the signal is a
fraction of a sine sweep from a loudspeaker that suffers
from rub and buzz. In Figure 1B the signal in Figure 1A
is band-pass filtered, and in Figure 1C the signal is the
envelope of the band-pass filtered signal.
30

Measurement set-up
Figure 2A shows a typical measurement set-up. The test
object is a loudspeaker, but the invention is useful also
to other audio devices such as amplifiers or other
5   equipment in an audio chain. A signal generator is used
to supply the loudspeaker with an excitation signal, e.g.
a sinusoidal signal. Preferably, a swept sine wave signal
is used as excitation signal, where the frequency of the
sine wave signal is varied eg linearly or logarithmically
10   between a lower limit and an upper limit. Alternatively,
the frequency can be stepped through the frequency range
of interest with the frequency being kept substantially
constant for a predetermined period of time, which can
vary with the frequency.

15

The sound output from the loudspeaker is picked up by a
microphone and fed to a transient analyser implemented in
a properly programmed computer, eg by means of the
HARMONI™ software from the applicant. With proper signal
20   conditioning the received signal is passed on to the
sound card in the PC. Such a system is shown
schematically in Figure 6.

Measurement and calculations
25   Pulses with short rise time or fall time, eg pulses
termed as rub and buzz, will contain a broad spectrum of
frequencies. Therefore it is possible to detect the
instantaneous energy by detecting the energy in frequency
bands in an interval in the transient or pulse oriented
30   range of the ear. According to the invention a method for
doing this is to use a filter bank containing a group of
band-pass filters covering the frequency interval of
interest, and rectify and low-pass filter the outputs

from the filter bank. The output from the low-pass filters is an expression for the square root of the energy. To be able to measure and detect the dynamic instantaneous energy of a signal, it is crucial that the

5   duration impulse response of the filters are sufficient shorter than the energy pulses signal.

Fig. 7 shows the principle of the edge or slope detection. The envelope signal is differentiated, and if

10   the differentiated signal numerically exceeds a trigger level, which level can be adjusted by the user, a leading edge or a trailing edge is detected. Numerically the maximum slope of the leading or trailing edge is detected by finding the numerically local maximum of the

15   differentiated envelope signal. Two thresholds define the beginning and ending of an edge. The edge begins where the differentiated envelope signal is equal to the threshold for the beginning of the edge before the local maximum, and it ends where the signal is equal to the

20   threshold for the ending of the edge after the local maximum. The thresholds are expressed as a percentage of the maximum slope.

Figure 2 shows a practical set-up for measuring the

25   energy as expressed in eq. (1). The set-up in Figure 2 comprises a band pass filter followed by a rectification followed by a low pass filter. This method can be characterised as transient analysis as energy detection by means of envelope detection. The rub and buzz shown in

30   Figure 1 is found by this method.

The band pass filters are selected in accordance with the critical bands described by amongst others E. Zwicker [2]. Each band pass filter thus covers substantially one critical band. The purpose of the band pass filters is

5   that the energy is found in frequency bands. The benefit of finding the energy in this way is that the changes in the instantaneous energy are detected and measured substantially as it is perceived by the human ear.

10   The low pass filters are preferably chosen in a way that ensures that no or only an insignificant overlap exists between the band pass filter and the low pass filter. In order for the method to detect rapid changes it is desirable that the low pass filter has a cut off

15   frequency as high as possible. The low pass filter is therefore chosen as a compromise between these 2 constrains. It is believed that this compromise also exists in the human ear.

20   In [1] a realisation of the transient analyser with 6 frequency bands each having a band pass filter, a rectifier and a low pass filter is described.

In order to get an interpretable result it is necessary

25   to find a way to express the changes in the instantaneous energy. The changes in the energy can be conceived as pulses. The pulses can be characterised by their magnitude, steepness and/or rise and fall time. By using one or more of these metrics it is possible to set up

30   appropriate limits in a QC system with reference to a pass/fail procedure.

Practical implementation and measurement

The measurement method is preferably implemented in software such as HARMONI™ from the applicant, which software is described in the product specification sheet

5   "Transient Analyser - HARMONI™Lab" [3]. The software has 6 channels or bands each having a band pass filter, a rectifier and a low pass filter as in Figure 2 and described above. The filters and also the number of bands can be changed by the user.

10

Figure 6 shows an equipment for a practical measurement could consist of a microphone with proper signal conditioning, a computer with a sound card, and an amplifier.

15

The signal that is applied to the terminals of the loudspeaker is a swept sine as this has proven to be effective to find rub and buzz. Other types of signal like white or pink noise, MLS (Maximum Length Sequence)

20   may prove to be useful but this has not been examined. Using a sweep has the advantage that it is possible to track at which frequencies the rub and buzz is excited.

Filter Bank – Low and Band-pass filters

25   The background for using band-pass filters is based on the assumption that the ear can be divided into several filters as reported by amongst other E. Zwicker.

The purpose of the band pass filters is to detect the

30   pulse in the frequency band where the pulse has most energy as perceived by the human ear. It will be the filter where the shape of the impulse response best matches the shape of the pulse. The theoretical optimal

match is an impulse response with a shape equal the pulse but reverse in time. In many cases the pulses will decline exponentially and it would not be possible to have a stable causal filter with an impulse response that is exponentially increasing without being unstable.

A reasonable choice of filters that matches the filters in the cochlea is band-pass filters with the same value for Q equal to about 2.8.

Band #	Frequency limits (−3 dB) in Hz
1	1400 − 2000
2	2000 − 2860
3	2800 − 4000
4	4000 − 5720
5	5700 − 8150
6	8100 − 11580

The transient analyser preferably allows the user to define his own filters. Two types of Band-pass filters are preferred: the Butterworth and the RealPole type (see below). The RealPole type is chosen as default. The Butterworth filters are 6th order band pass filter with a maximally flat stop and pass. The RealPole filters are 14th order band pass filters, with the same bandwidth as the Butterworth type.

To detect the energy in the bands the output signal from the band-pass filters has to be rectified and low-pass filtered. The spectrum of band-pass filters and the low-pass filters should not overlap each other. The filters are therefore chosen to have a cut-off frequency half the bandwidth of the band-pass filters for the Butterworth types of filters and a third of the bandwidth for the RealPole types.

	Band #	Low Pass (- 3 dB) Band in Hz for the Butterworth type
	1	300
	2	430
5	3	600
	4	860
	5	1225
	6	1740

	Band #	Low Pass (- 3 dB) Band in Hz for RealPole type
10		
	1	200
	2	287
	3	400
15	4	574
	5	817
	6	1160

The Butterworth filters' impulse responses have a long
20   ringing tail. This ringing causes unwanted small
transients to be detected, which do not correspond to
actual conditions in the device under test. The RealPole
filter type is based on a low pass filter with roots only
on the negative real axis in the analogue S-domain. These
25   filters are transformed to Band Pass filters, before the
finally transformation to the digital domain. In theory
the impulse response of the filters is infinite but in
practice it has finite duration. The shorter the duration
is for the impulse response the better is the time
30   resolution, but the shorter the impulse response is, the
less the frequency selection is. Therefore there is a
limit on how short the impulse response can be, because

the spectrum of the band pass filter and low pass filter
must not overlap each other. If they do the envelope
detection will be mixed with frequencies.

5   **Pulse detection**
     Figures 1A-C show an example of pulses detected in one of
     the bands. In figure 1A the signal is the output from a
     loudspeaker that suffers from rub and buzz, in response
     to a short sine sweep. In Figure 1B the signal is band-
10   pass filtered, and in Figure 1C the signal is the
     envelope of the band-pass filtered signal.

     Figure 7 shows the principle of the edge detection. The
     envelope signal is differentiated, and if the
15   differentiated signal numerically exceeds a predefined
     trigger level, which level can be adjusted by the user, a
     leading edge or a trailing edge is detected. Numerically
     the maximum slope of the leading edge or trailing edge is
     detected by finding the numerically local maximum of the
20   differentiated envelope signal. Two thresholds define the
     beginning and ending of an edge. The edge begins where
     the differentiated envelope signal is equal to the
     threshold for the beginning of the edge before the local
     maximum, and it ends where the signal is equal to the
25   threshold for the ending of the edge after the local
     maximum. The thresholds are expressed as a percentage of
     the maximum slope.

     Masking trigger level with exponential damping
30   It might be convenient to reduce the amount of edges. If
     a pulse with less maximum instantaneous energy or longer
     rise/fall time follows a pulse it might not detected by
     the ear. Therefore it is possible to choose a special

trigger mode called "Masking Trigger". The principle is shown on fig. 13. Fig. 13 shows two pulses with different steepness for the leading and trailing edges. When the first leading is detected the trigger level is increased

5   to the maximum level of the differentiate pulse, and decreased exponentially by the trigger time constant. The trailing edge is less steep than the leading edge and the trigger time constant is to great, and the trailing edge is not detected. The leading edge of the next pulse is

10   detected because the trigger level is decreased to a level less than maximum of the differentiated pulse.

A reasonable choice for the trigger time constant is in the interval 1 - 3 ms..

15

Examples
Below, three examples are given for which rub and buzz tests have been carried out. The tests have been carried out on 3 types of transducers. The measurement setup and

20   software were as described above.

In Figures 3A-B, 4A-C and 5A-C the abscissa is a time scale from 0 to 2 s. With a swept frequency excitation signal each point on the abscissa time scale also

25   represents a distinct frequency depending on the chosen frequency limits and sweep characteristics. The ordinate represents the steepness of pulses in the sound output signal of the transducer under test as measured above.

30   Figures 3A-B show screen dumps from HARMONI[TM] transient analyser software with the result of a transient analysis for a good 15 mm transducer and a bad one suffering from

rub and buzz, respectively, both intended for use in
mobile phones. The applied signal was a linearly swept
sine from 300 Hz to 1 kHz.

5   In Figures 3A-B the dots show the detected pulses derived
from measurement of the instantaneous energy. Each curve
represents one of the 6 bands. The steepness is plotted
against time, and the x-axis therefore represents a
linear frequency scale from 20 Hz to 100 Hz.

10

From Figure 3B it can be seen that the bad transducer, which suffers from rub and
buzz, has a very easily detected rub and buzz in a limited frequency range
corresponding to the time when the sweep is passing about 550 Hz. The difference
between the good and the bad transducer suggest that a pass/fail limit of about 5-6

15   dΔPascal/s [re 1 Pa/s] would be appropriate to catch the transducers with defects.

Figures 4A-C shows the result of an analysis of a good
and 2 defect 10 cm midrange speaker. The test signal was
a swept sine from 20 Hz to 100 Hz. The steepness is

20   plotted against the time and the x-axis may therefore be
conceived as a linear frequency scale from 20 Hz to 100
Hz. Figure 4 indicates that a pass/fail limit of about
0.5 dΔPascal/s [re 1 Pa/s] would be appropriate.

25   Figure 5 shows the result of a transient analysis on
three 25 mm tweeters. One tweeter is without rub and
buzz, one has a dragging coil defect and one has an air
leak. The test signal was a swept sine from 20 Hz to 500
Hz. The steepness is plotted against the time and the x-

30   axis may therefore be conceived as a linear frequency
scale from 20 Hz to 100 Hz. A pass/fail limit of about
0.5 ΔPascal/s [re 1 Pa/s] would be appropriate.

16

In general the pass/fail limit can be set as a fixed
value for all bands or a value can be set for each band.
Further when a sweep is used as excitation signal it is
also possible to set a limit as a function of the
5 excitation frequency. The limit(s) should reflect the
level of acceptance.

An AGC (automatic gain control) amplifier is an option to
simulate the masking effect in frequency. When the energy
10 i.e. loudness increases to a large value in one of the
frequency bands, the AGC connected to the band will
decrease the signal, stopping the edge detection. The AGC
amplifier can be expressed with the equation:

$$\frac{1}{1+K_{AGC}\langle x(t)\rangle},$$

15

where x(t) is the input signal (from the low pass
filters) and K_{AGC} is a constant.

$\langle x(t)\rangle$ is the average (DC) at time t. In HARMONI Lab it is
20 an exponential average estimate, where the past values is
weighted after an exponential window. With the time
constant τ, the averaging speed is set. Generally applies
that larger τ values gives a better average estimate, but
a worse time resolution.

25

Literature

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Research A/S.

30

[2] E. Zwicker, H. Fastl: "Psychoacoustics - Facts and Models".
Springer Series in Information Sciences.

[3]   Product specification sheet "Transient Analyser
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[4]   A. B. Carlson: "Communication Systems: An
        Introduction to Signals and Noise in Electrical
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        auditory speech processing". Journal of Phonetics
        (1988) 16. 55-76.

15

Claims

1. A method of testing an electro-acoustic device, the method comprising

5

- supplying a test signal to the device causing the device to respond with a response signal,

- capturing the response signal,

10

- analysing the captured response signal for transients, and

- deriving, from the transients, information indicative
15 of the transients.

2. A method according to claim 1, c h a r a c t e r -
i z e d in that the derived information indicative of the transients is chosen from the group consisting of
20 steepness, rise time and magnitude.

3. A method according to claim 1, c h a r a c t e r -
i z e d in that the step of analysing the captured response signal for transients comprises

25

- band pass filtering the captured response signal to obtain a band pass filtered signal,

- determining an envelope of the band pass filtered
30 signal.

4. A method according to claim 3, c h a r a c t e r -
i z e d in that the step of determining an envelope of
the band pass filtered signal comprises

5   - rectification of the band pass filtered signal to
obtain a rectified signal, and

- low pass filtering the rectified signal.

10   5. A method according to claim 3, c h a r a c t e r -
i z e d in that

- the captured response signal is band pass filtered in a
plurality of band pass filters to obtain a plurality of
15   band pass filtered signals, that

- each band pass filtered signal is rectified to obtain
respective rectified signals, and that

20   - each rectified signal is low pass filtered.

6. A method according to claim 1, c h a r a c t e r -
i z e d in that the step of deriving information
indicative of steepness of the transients comprises
25   differentiation of the transients.

7. A method according to claim 1, c h a r a c t e r -
i z e d in that the information indicative of steepness
of the transients is compared to a predefined threshold
30   value.
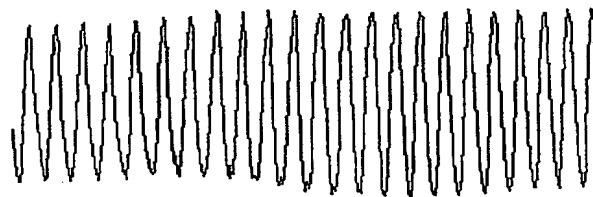
Fig.1A Sine wave sweep with Rub and Buzz

Fig. 1B Band-pass filtered signal

Fig 1C Instantaneous energy pulses
caused by Rub and Buzz
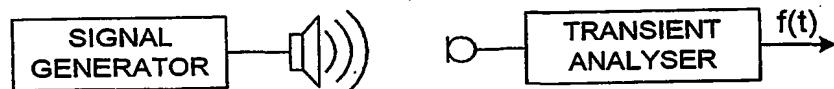
Fig. 2A Transient analysis setup
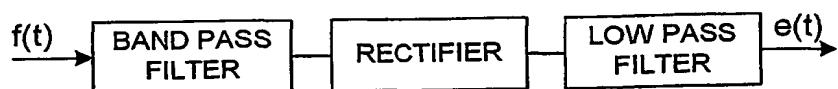
Fig. 2B Energy detection by means of envelope detection
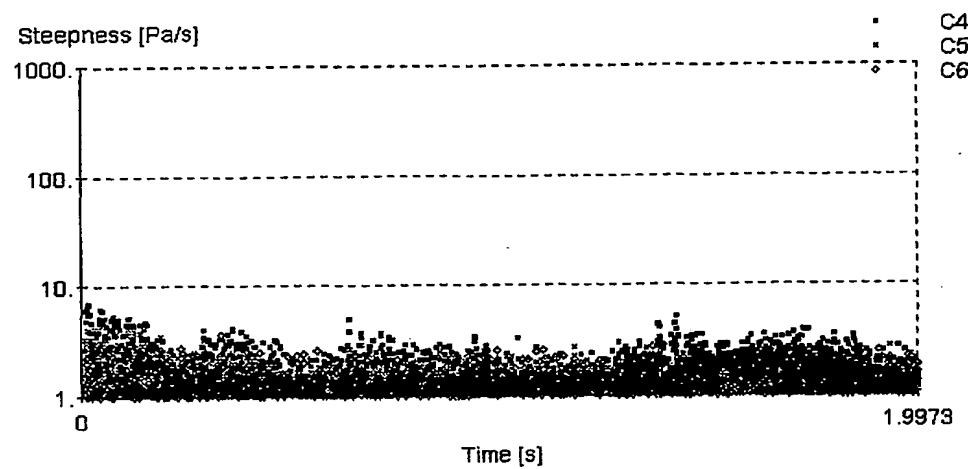
Fig. 3A Transducer without Rub and Buzz
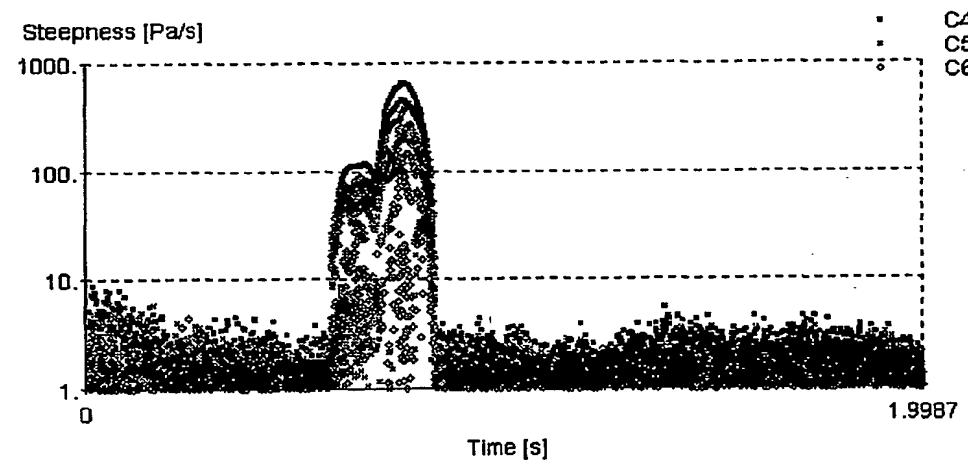
Fig. 3B Transducer with Rub and Buzz
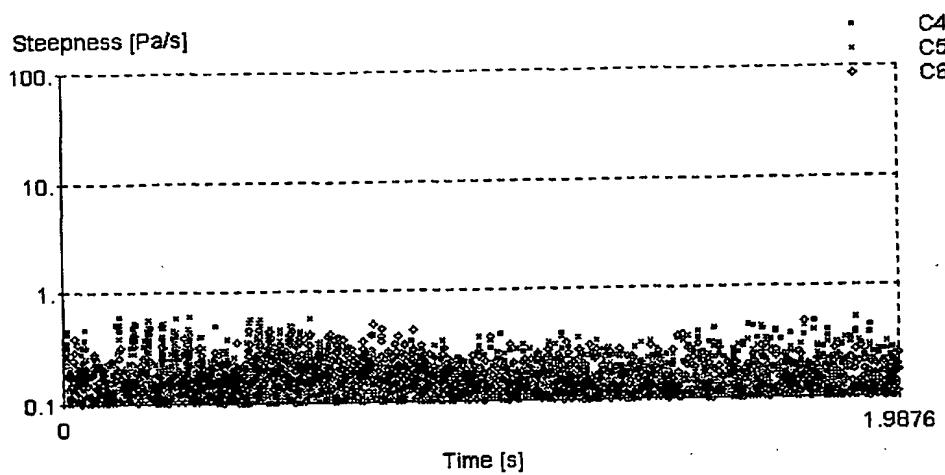
Fig. 4A Loudspeaker without Rub and Buzz
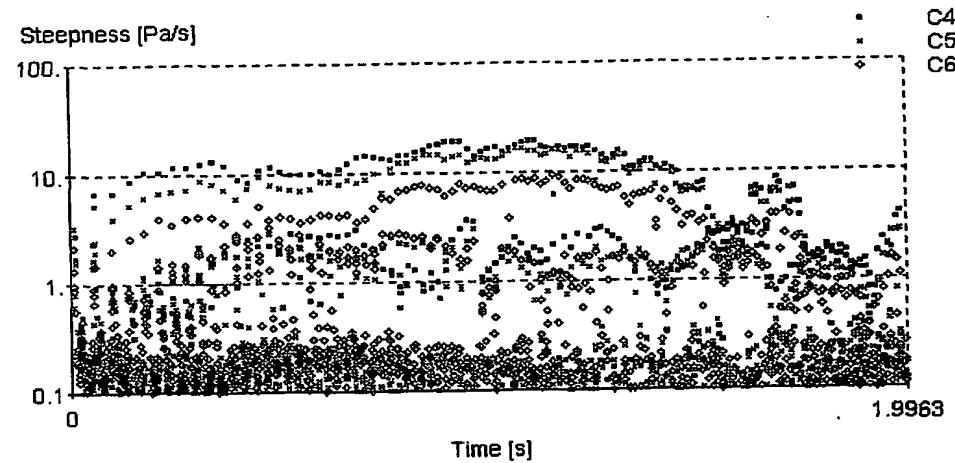
Fig. 4B Loudspeaker with dragging coil
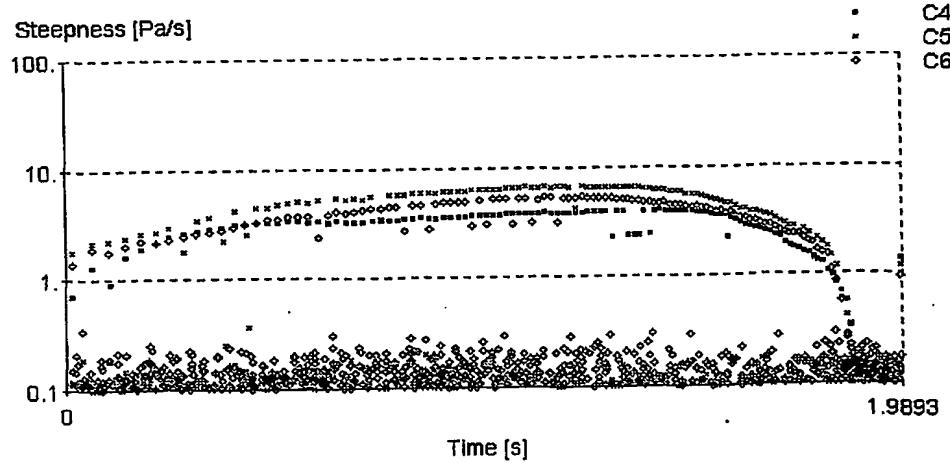

Fig. 4C Loudspeaker with litz wire defect

Steepness [Pa/s]   · C4
                                                                   · C5
100.   ◇ C6

10.

1.

0.1
   0   ·1.9943
                        Time [s]

Fig. 5A Tweeter without Rub and Buzz

Steepness [Pa/s]   · C4
                                                                   · C5
100.   ◇ C6

10.

1.

0.1
   0   1.9943
                        Time [s]
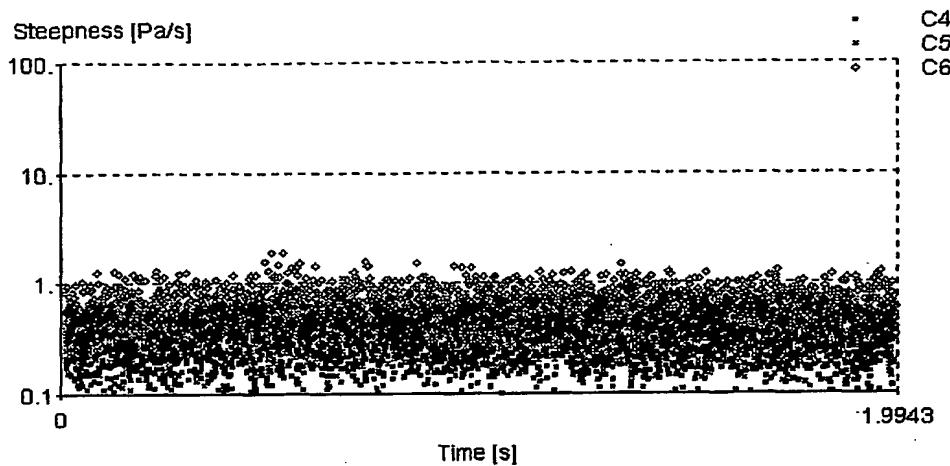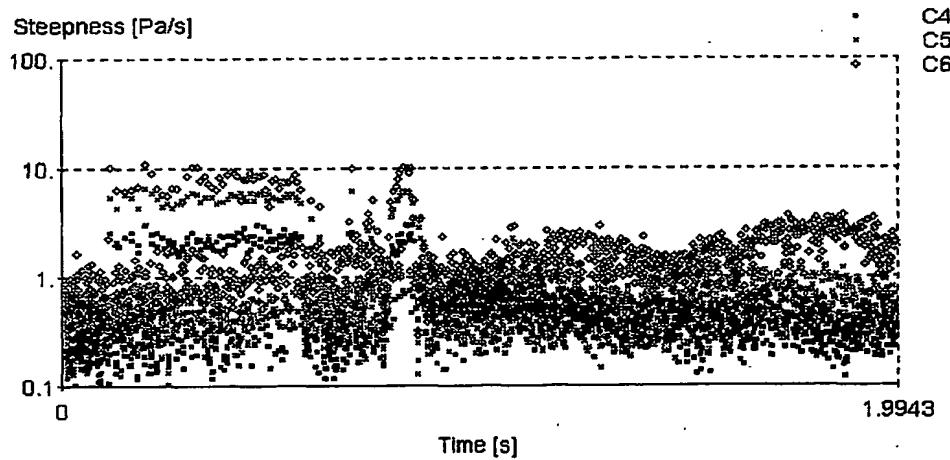
Fig. 5B Tweeter with dragging coil

Steepness [Pa/s]   · C4
                                                                   · C5
100.   ◇ C6

10.

1.

0.1
   0   1.9943
                        Time [s]
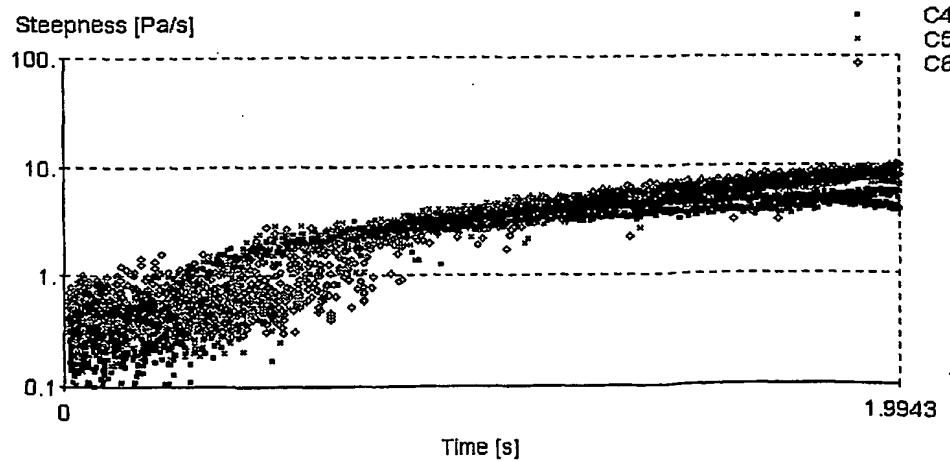
Fig. 5C Tweeter with air leak

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5/5
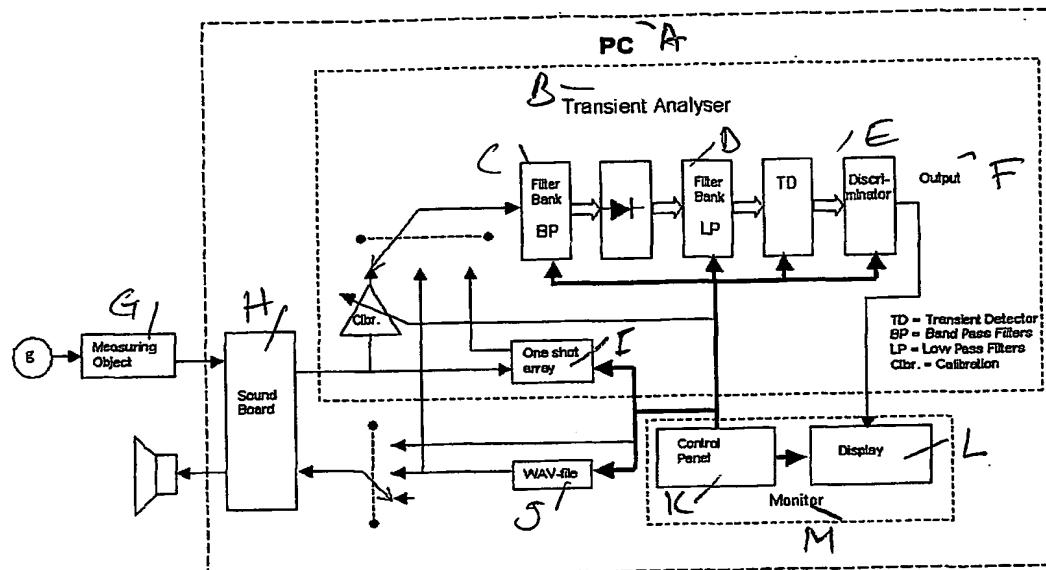
Fig. 6 Block diagram of transient analyser
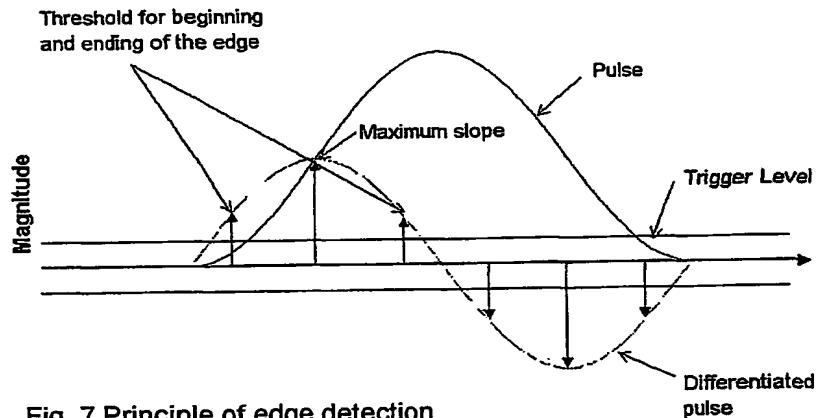
Fig. 7 Principle of edge detection
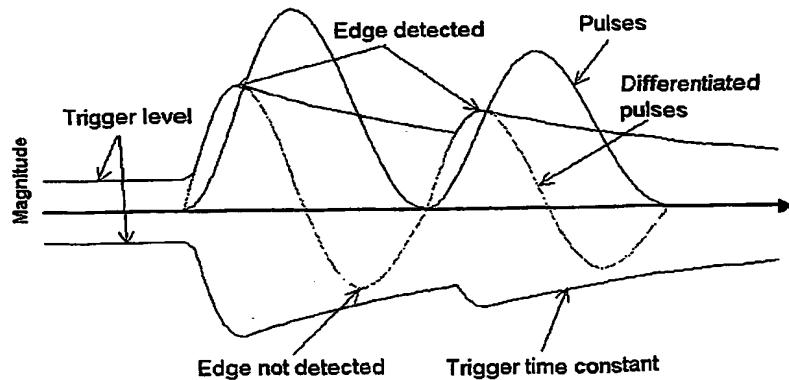
Fig. 8 Masking edge detection

INTERNATIONAL SEARCH REPORT

International application No.
PCT/DK 01/00605

A. CLASSIFICATION OF SUBJECT MATTER

IPC7: H04R 29/00 // G10L 17/00, G10L21/00

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC7: H04R, G10L

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

SE,DK,FI,NO classes as above

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

EPO-INTERNAL, WPI DATA

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	WO 9425958 A2 (LEONARD, F.U.), 10 November 1994 (10.11.94), the whole document	1-7
X	WO 9709712 A2 (LEONARD, F.U.), 13 March 1997 (13.03.97), the whole document	1-7
A	WO 9948085 A1 (LEONARD, F.U.), 23 Sept 1999 (23.09.99)	1-7
P,A	WO 0131632 A1 (THE UNIVERSITY OF MELBOURNE), 3 May 2001 (03.05.01)	1-7

☐ Further documents are listed in the continuation of Box C. ☒ See patent family annex.

Date of the actual completion of the international search	Date of mailing of the international search report
21 January 2002	2 6 -01- 2002
Name and mailing address of the ISA/ Swedish Patent Office Box 5055, S-102 42 STOCKHOLM Facsimile No. +46 8 666 02 86	Authorized officer Henrik Andersson /OGU Telephone No. +46 8 782 25 00

Form PCT/ISA/210 (second sheet) (July 1998)

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